



Software Management by Numbers

Towards an Engineering Discipline

SE-CURE AG (www.se-cure.ch)

Dr. Hans Sassenburg

T +41 33 733 4682

M +41 79 231 6600

E hsassenburg@se-cure.ch





Contents

1. Software Industry Today
2. Empirical Information
3. Key Performance Indicators
4. Products and Services
5. Case Study Examples
6. Conclusions



Questions ...

- Did you ever go after the world's next model/standard or hype?
 - *If yes, how (much) did it help you?*
- Are you able today to tell what targeted, actual and historical values of your main KPIs are?
 - *If not, would you be interested to know?*



Software Industry Today

- The software industry still isn't doing a very good job at managing by the numbers

"Oftentimes, software projects are managed by just three metrics: schedule/effort and critical defects found during testing"

- This is a flatland view for a multi-dimensional terrain problem: "flying a plane using only a watch and a fuel gauge"
- Other metrics must be in the equation as well, representing what will be built (product scope/quality) and how it is built (process)



Biking (1/3)

Summary:

32.67 km
2 h 18 min



Question:

Am I fit?

My home

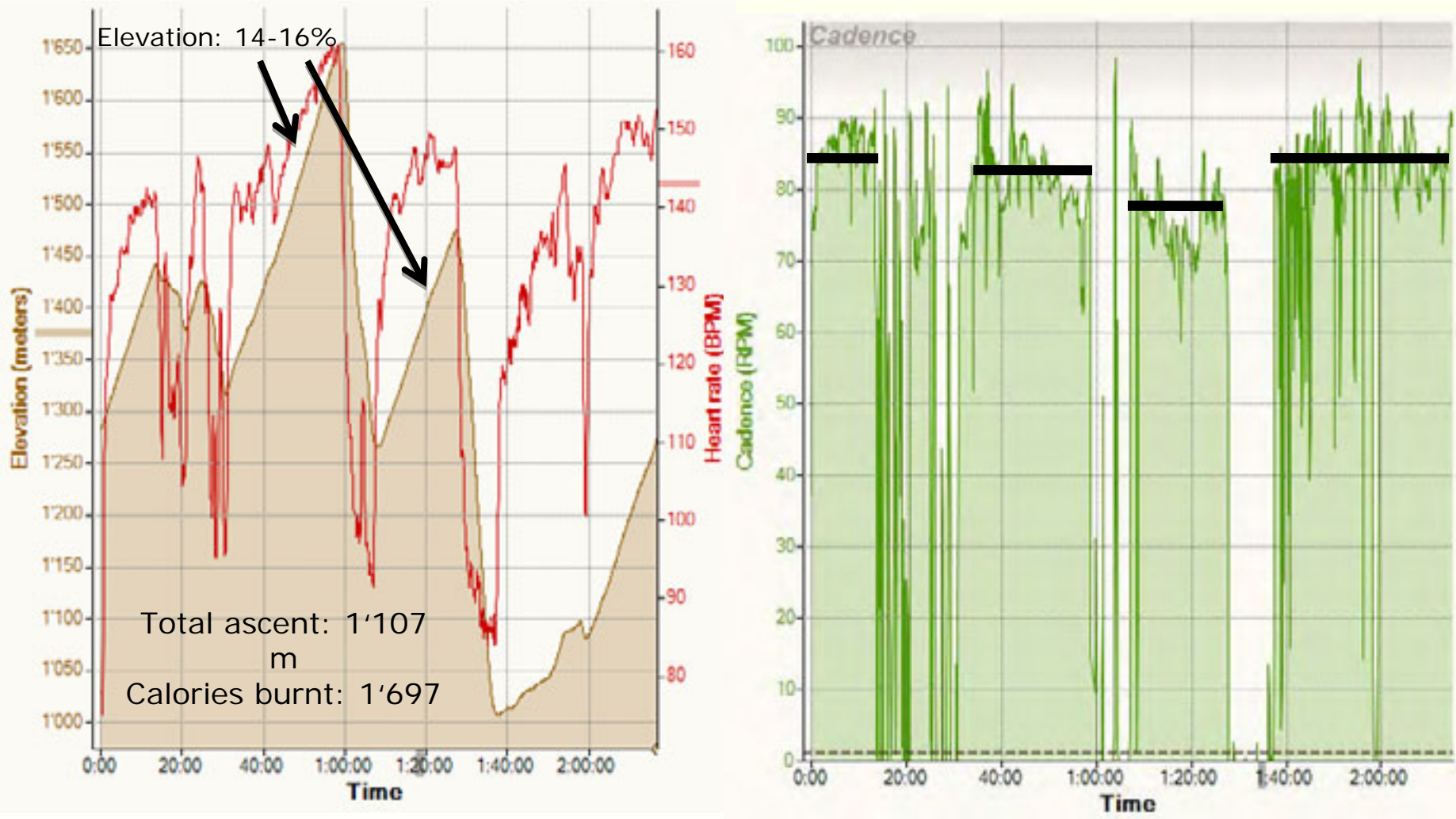


Mountain Biking (2/3)





Mountain Biking (3/3)





Problem Statement

***"You can't fix
what you refuse to measure"***

- When quantitative information is missing:
 - Management is like an emperor without clothes: decisions are not based on facts
 - Improvement initiatives result in satisfying standards/models instead of tangibly improving measured capability



What is Improvement?

- It is NOT about
 - Satisfying a model/standard
 - Implementing the next hype
- It is about becoming
 - More predictable (performance)
 - Faster (efficiency)
 - More effective (scope)
 - Better (quality)



Being Successful

- Knowing the (performance) **capability** of your organization through the collection and analysis of historical data
- Making **credible commitments** in terms of what will be delivered when against what cost
- Managing **development** once it starts; this requires earned value management, activity distribution management and effective scope and quality management
- Analyzing the **impact of new initiatives** by assessing how capability is affected in which areas; this prevents organizations from chasing hypes

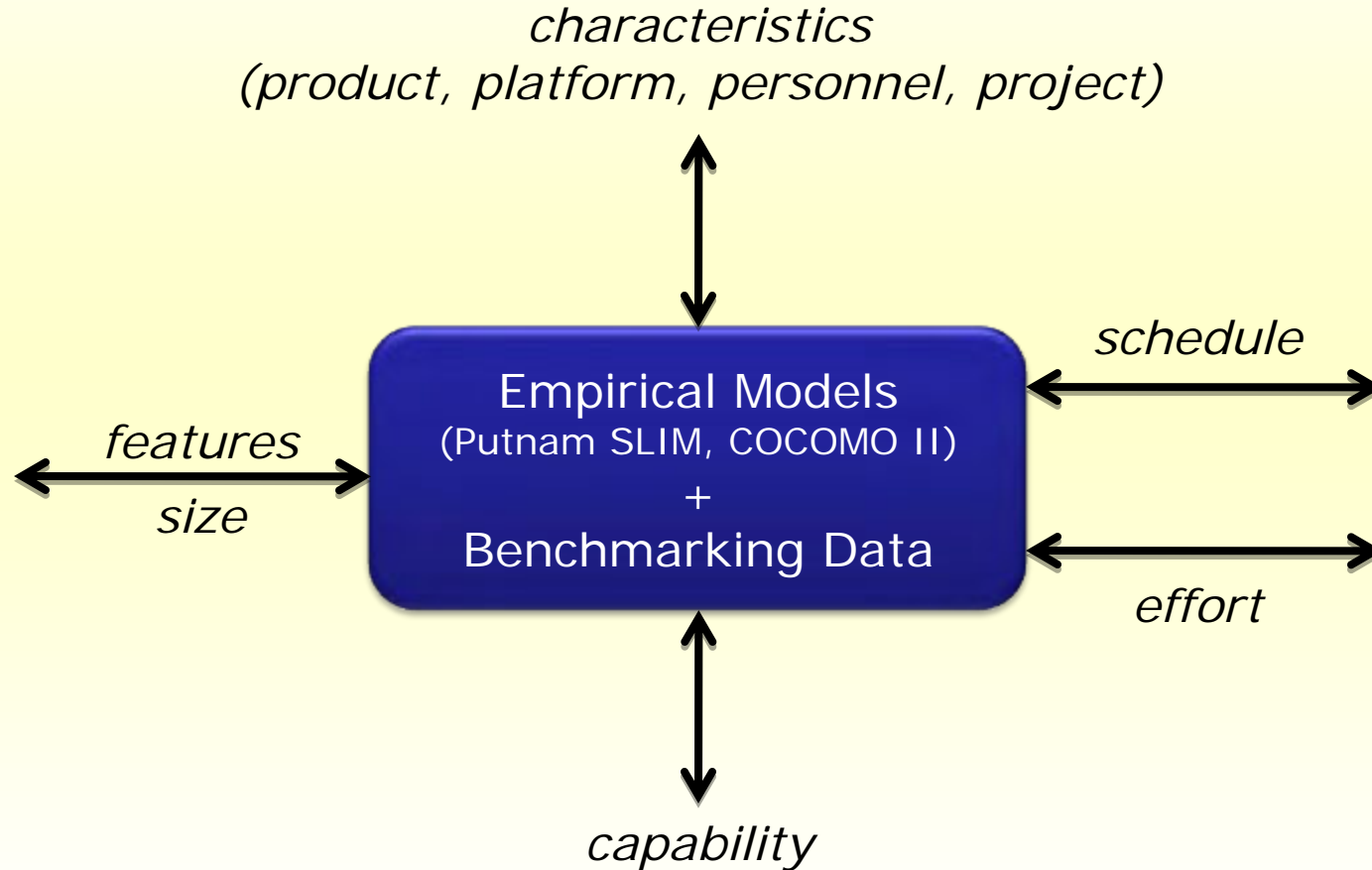


2. Empirical Information

- Empirical Models
 - Putnam SLIM
 - COCOMO II
- Empirical Laws
 - Minimal development time!
- Benchmarking Data
 - Guru: Capers Jones
- Observation
 - Availability hardly known, seldom used ...

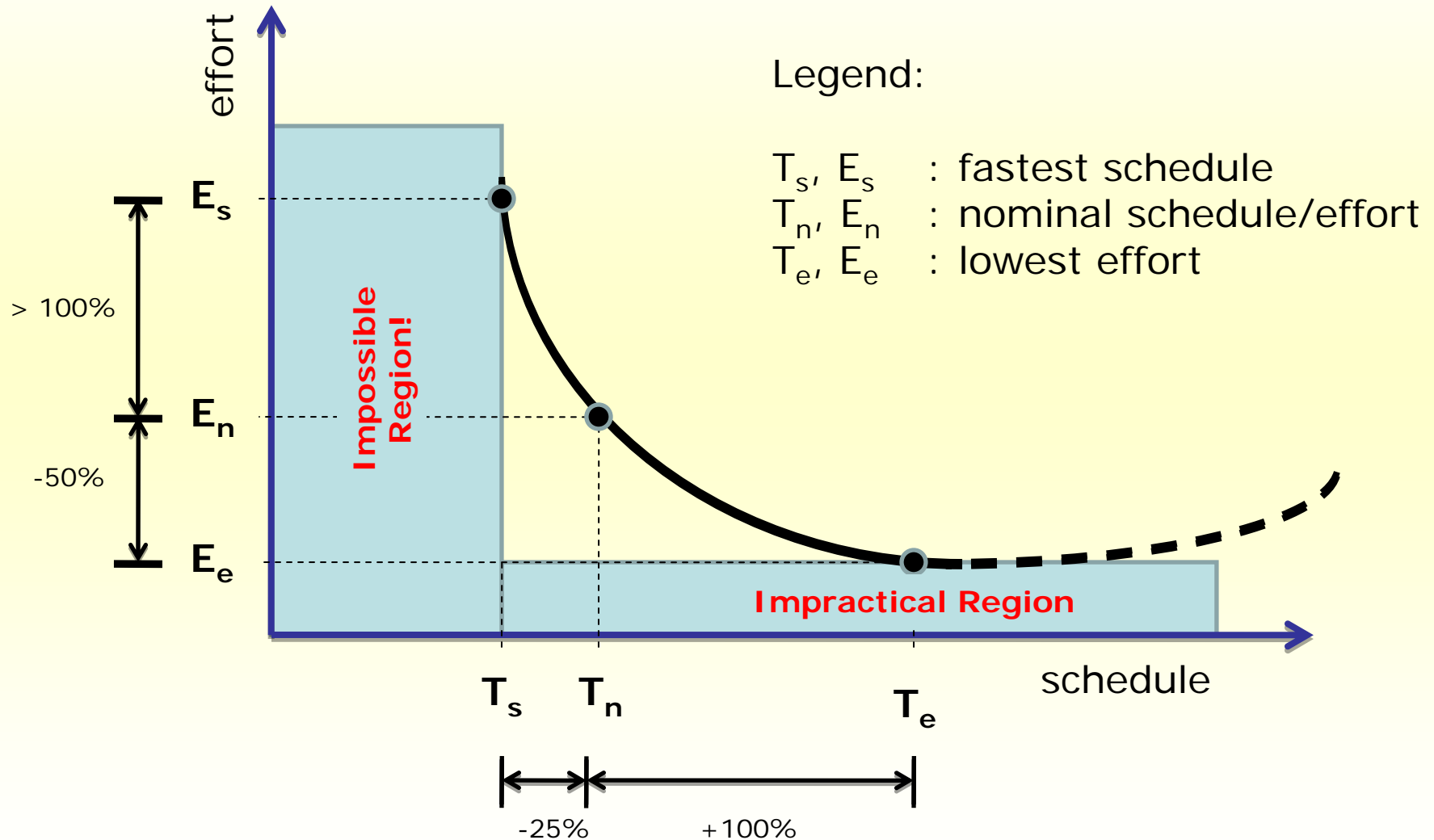


Empirical Models





Empirical Laws



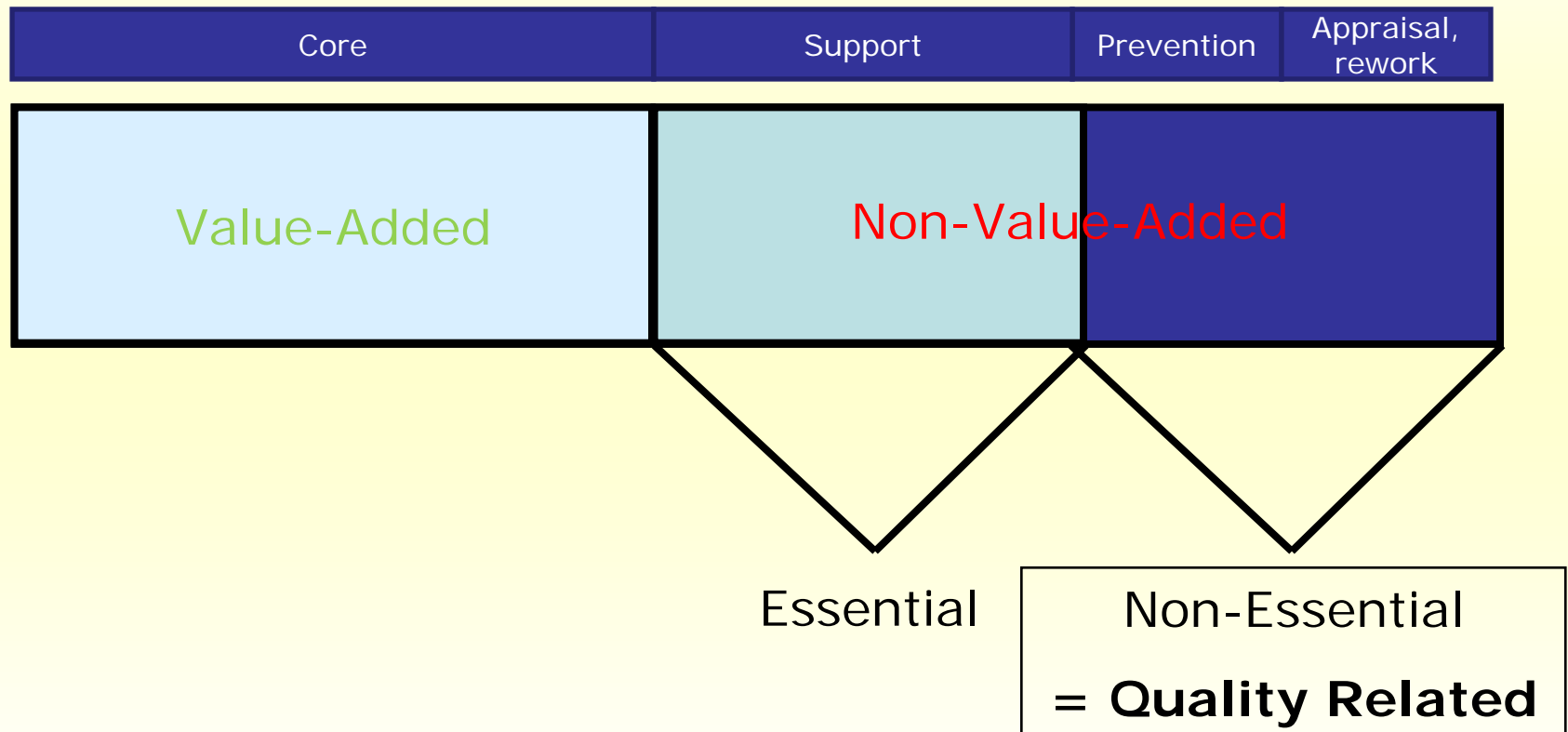


Benchmark (Jones 2008)

Schedule (months)	MIS		Outsource		Commercial		Systems		Military		Web	
	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best
100 FPs	6.00	4.50	7.00	4.25	8.00	5.00	9.00	5.00	10.00	6.00	3.00	2.00
1'000 FPs	18.00	12.00	19.00	11.00	22.00	12.00	24.00	14.00	36.00	16.00	10.00	10.00
10'000 FPs	48.00	24.00	47.00	23.00	46.00	24.00	45.00	28.00	60.00	32.00	40.00	18.00
100'000 FPs	68.00	52.00	63.00	50.00	64.00	48.00	63.00	48.00	72.00	54.00	-	-
Effort (staff months)	MIS		Outsource		Commercial		Systems		Military		Web	
	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best
100 FPs	4.8	1.0	5.3	0.9	9.1	1.0	11.1	1.3	17.9	1.8	4.0	0.8
1'000 FPs	61.0	20.0	63.3	16.7	107.5	16.7	144.9	20.0	208.3	33.3	4.6	13.3
10'000 FPs	2'150.5	666.7	2'127.7	625.0	2'173.9	666.7	1'960.8	666.7	2'631.6	1'000.0	5.6	400.0
100'000 FPs	37'037.0	16'666.7	33'333.3	14'285.7	25'000.0	10'526.3	24'096.4	13'333.3	47'619.1	14'285.7	-	-
Productivity (FP per staff month)	MIS		Outsource		Commercial		Systems		Military		Web	
	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best
100 FPs	21.00	100.00	19.00	115.00	11.00	100.00	9.00	80.00	5.60	55.00	47.30	125.00
1'000 FPs	16.40	50.00	15.80	60.00	9.30	60.00	6.90	50.00	4.80	30.00	25.60	75.00
10'000 FPs	4.65	15.00	4.70	16.00	4.60	15.00	5.10	15.00	3.80	10.00	12.00	25.00
100'000 FPs	2.70	6.00	3.00	7.00	4.00	9.50	4.15	7.50	2.10	7.00	-	-
Defect Potentials (per FP)	MIS		Outsource		Commercial		Systems		Military		Web	
	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best
100 FPs	4.00	1.75	4.10	1.60	4.00	2.00	5.00	2.25	5.50	2.50	4.00	1.50
1'000 FPs	5.00	2.75	5.05	2.60	5.00	3.00	6.00	3.30	6.75	3.65	4.60	2.25
10'000 FPs	6.00	3.50	6.30	3.30	6.40	3.60	7.00	3.80	7.80	4.00	5.60	2.75
100'000 FPs	7.25	4.60	7.40	4.50	7.70	4.50	8.00	4.40	8.50	4.80	-	-
Removal Efficiency	MIS		Outsource		Commercial		Systems		Military		Web	
	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best
100 FPs	92.0%	97.0%	90.0%	98.0%	94.0%	97.0%	97.0%	98.5%	96.0%	98.0%	87.0%	99.5%
1'000 FPs	85.0%	96.0%	84.0%	97.0%	92.0%	95.0%	96.0%	96.5%	93.0%	96.0%	87.0%	97.0%
10'000 FPs	61.0%	94.0%	82.0%	95.0%	90.0%	93.5%	95.0%	96.0%	92.0%	95.5%	82.0%	94.5%
100'000 FPs	65.0%	92.5%	70.0%	93.5%	88.0%	92.5%	93.0%	95.0%	91.0%	95.0%	-	-
Defect Density (per FP)	MIS		Outsource		Commercial		Systems		Military		Web	
	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best	Average	Best
100 FPs	0.32	0.05	0.41	0.03	0.24	0.06	0.15	0.03	0.22	0.05	0.52	0.01
1'000 FPs	0.75	0.11	0.81	0.08	0.40	0.15	0.24	0.12	0.47	0.15	0.60	0.07
10'000 FPs	1.14	0.21	1.13	0.17	0.64	0.23	0.35	0.15	0.62	0.18	1.10	0.15
100'000 FPs	2.54	0.35	2.22	0.29	0.92	0.34	0.56	0.22	0.77	0.24	-	-



Cost Categories



Benchmark - Process Efficiency

(Jones/Sassenburg)



	MIS				Outsource				Commercial				Systems				Military				Web			
	C	S	P	A/R	C	S	P	A/R	C	S	P	A/R	C	S	P	A/R	C	S	P	A/R	C	S	P	A/R
Requirements	7.5%				9.0%				4.0%				4.0%				7.0%							
Prototyping			2.0%				2.5%				1.0%				1.0%			2.0%						10.0%
Architecture	0.5%				1.0%				2.0%				1.5%				1.0%							
Project plans		1.0%				1.5%				1.0%				2.0%				1.0%						
Initial design	8.0%				7.0%				6.0%				7.0%				6.0%							
Detail design	7.0%				8.0%				5.0%				6.0%				7.0%							
Design reviews							0.5%				1.5%				1.5%			1.0%						
Coding	20.0%				16.0%				23.0%				20.0%				16.0%				33.0%			
Reuse acquisition					2.0%				2.0%				2.0%				2.0%				5.0%			
Package purchase	1.0%				1.0%								1.0%				1.0%				1.0%			
Code inspections											1.5%				1.5%			1.0%						
Independent V&V																	1.0%							
Conf. management		3.0%				3.0%				1.0%				1.0%				1.5%						
Formal integration				2.0%				2.0%				1.5%				2.0%				1.5%				
User documentation	7.0%				8.0%				12.0%				10.0%				10.0%				10.0%			
Unit testing				4.0%				3.5%				2.5%				5.0%				3.0%				30.0%
Function testing				6.0%				5.0%				6.0%				5.0%				5.0%				
Integration testing				5.0%				5.0%				4.0%				5.0%				5.0%				
Systems testing				7.0%				5.0%				7.0%				5.0%				6.0%				
Field testing												6.0%				1.5%				3.0%				
Acceptance testing				5.0%				3.0%								1.0%				3.0%				
Independent testing																				1.0%				
Quality assurance							1.0%				2.0%				2.0%			1.0%						
Installation/training		2.0%				3.0%								1.0%				1.0%				1.0%		
Project management		12.0%				12.0%				11.0%				12.0%				13.0%				10.0%		
%	51.0%	18.0%	2.0%	29.0%	53.0%	19.5%	4.0%	23.5%	54.0%	13.0%	6.0%	27.0%	51.5%	16.0%	8.0%	24.5%	51.0%	16.5%	5.0%	27.5%	49.0%	11.0%	10.0%	30.0%

Legend:

C = Core activities
 S = Support activities
 P = Prevention activities
 A/R = Appraisal, rework activities

Reference:

"Applied Software Measurement", Jones, 2008.
 McGraw-Hill, ISBN 978-0-07-150244-3.



3. Key Performance Indicators

"Getting too little or too much data is easy, identifying and extracting the relevant data and converting it to meaningful information for everyone is the challenge"



KPIs versus Metrics

- **KPIs (= meaningful information)** are meant to gauge progress toward or benchmark against vital, strategic objectives usually defined by upper management
- **Metrics (= data)** at a lower detail level are measured attributes of a process or a product
- The goal of KPIs is to foster greater visibility and faster reaction to opportunities and threats, hereby enabling informed decision-making



KPI Selection Criteria

- Must support **project management** in analysing, planning and monitoring projects
- Must inform **management** where a project stands and in what direction it is heading
- Must support **business units** in measuring their capability improvement over time
- Must support **organisations** in comparing/benchmarking business units



Questions to Answer

- Project Performance
 - What is the prediction of the performance of the project?
- Process Efficiency
 - How efficient is the development process?
- Product Scope
 - How large and stable is the scope of the planned effort in terms of features and size?
- Product Quality
 - What is the expected quality of the resulting product (reliability and maintainability)?



Derived KPI Categories

- Project Performance (= how predictable?)
 - Cost, schedule, staffing rate, productivity
- Process Efficiency (= how fast?)
 - Effort distribution (Cost of Quality model)
- Product Scope (= how much?)
 - Features, deferral rate, size, re-use
- Product quality (= how well?)
 - Complexity, test coverage, removal efficiency, defect density



Best Practice KPI Set

Project Performance	Product Scope
Schedule	Feature size
Budget	Deferred
Staffing rate	Size
Productivity	Re-use
Process Efficiency	Product Quality
Core	Complexity
Support	Test coverage
Prevention	Defect density
Appraisal/rework	Removal efficiency



Typical Maturization Effects

Project Performance		Product Scope	
Schedule	↘	Feature size	↘
Budget	↘	Deferred	↘
Staffing rate	↗	Size	↘
Productivity	↗	Re-use	↗
Process Efficiency		Product Quality	
Core	↗	Complexity	↘
Support	↗	Test coverage	↗
Prevention	↗	Defect density	↘
Appraisal/rework	↘	Removal efficiency	↗



Key Points to Remember

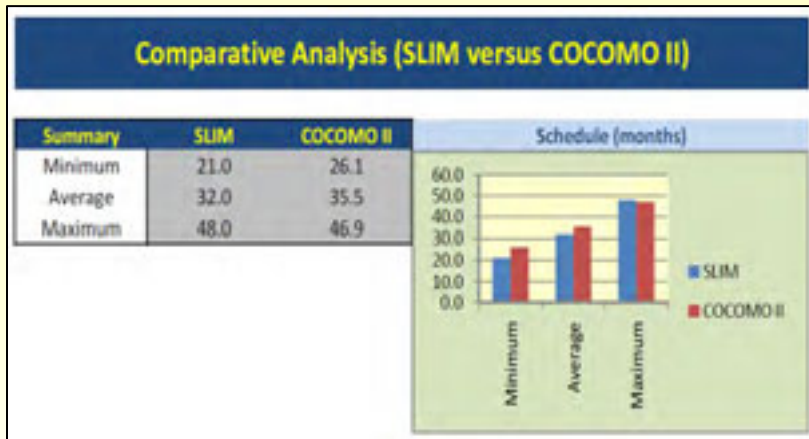
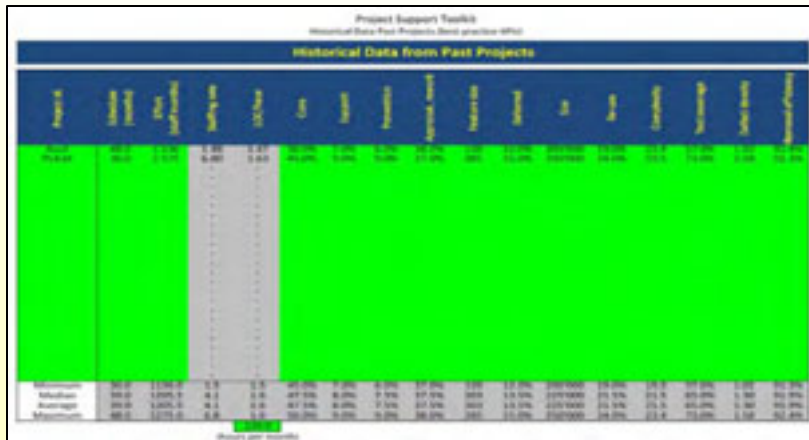
1. Assessing real software performance capability requires a **multi-dimensional view**
2. Compliance to process models and/or standards is **no guarantee** for high performance capability, although it may help (pragmatism versus bureaucracy)
3. The set of Key Performance Indicators allows measuring real performance capability **improvements** over time and **benchmarking**



4. Products and Services

- See www.se-cure.ch/Products.html
- See www.se-cure.ch/Services.html

Project Support Toolkit



The **Project Support Toolkit** provides powerful instruments to project managers and measurements specialists to plan, monitor and control their projects on a more detailed level, using the same set of KPIs as in the **Project Reporting Cockpit**.



1-Day Workshops



1. Software Capability
Improvement by
Numbers

2. Software Estimation
by Numbers

3. Software Planning
and Monitoring by
Numbers





5. Case Study Examples

- Context
 - 2 B2B manufacturers (Case A, case B)
 - Product functionality highly determined by software
 - Case A: applications are safety-critical
 - Case B: security of information is crucial
- Current performance
 - CMMI L2/3 (internal assessments)

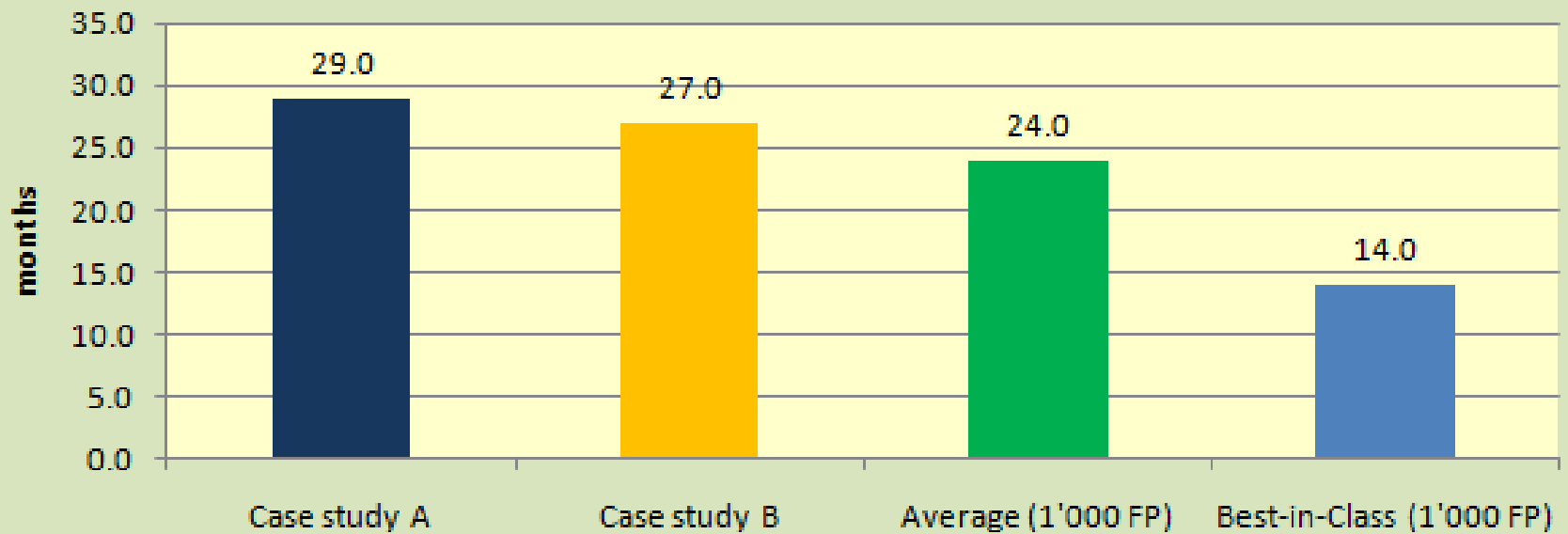


Issues

- No benchmarking data for deferral rate and re-use level
 - Context specific and lack of data
 - Finding: deferral rate unknown
- No benchmarking data for test coverage and complexity
 - Market ...!
 - Finding: test coverage unknown, complexity high
- Feature size (FP) = Product size (KLOC)?

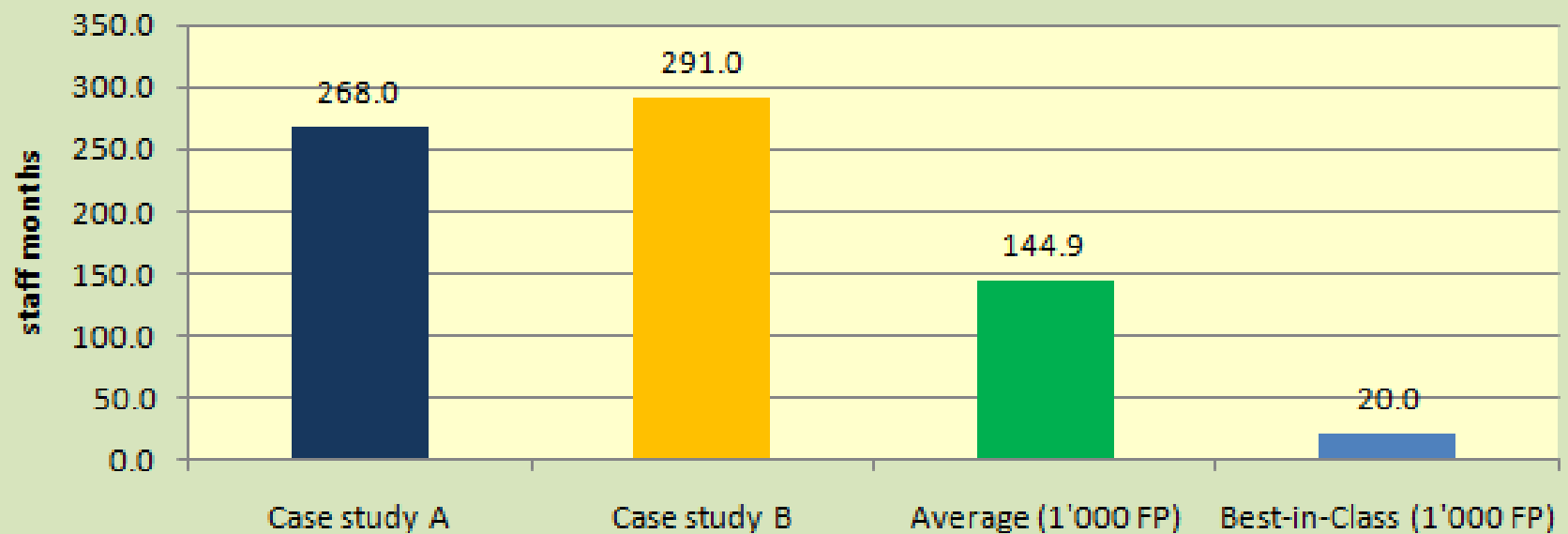


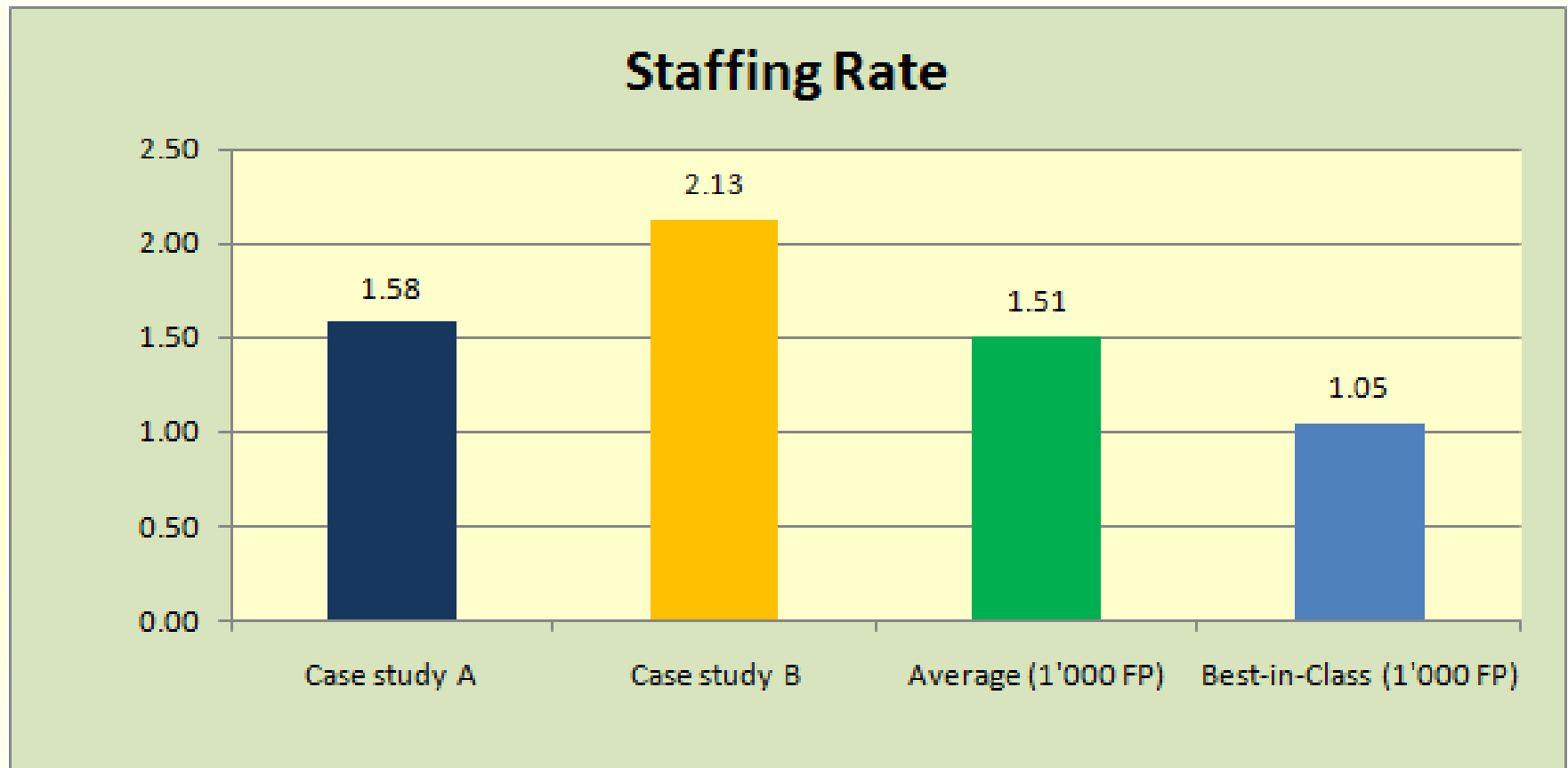
Schedule





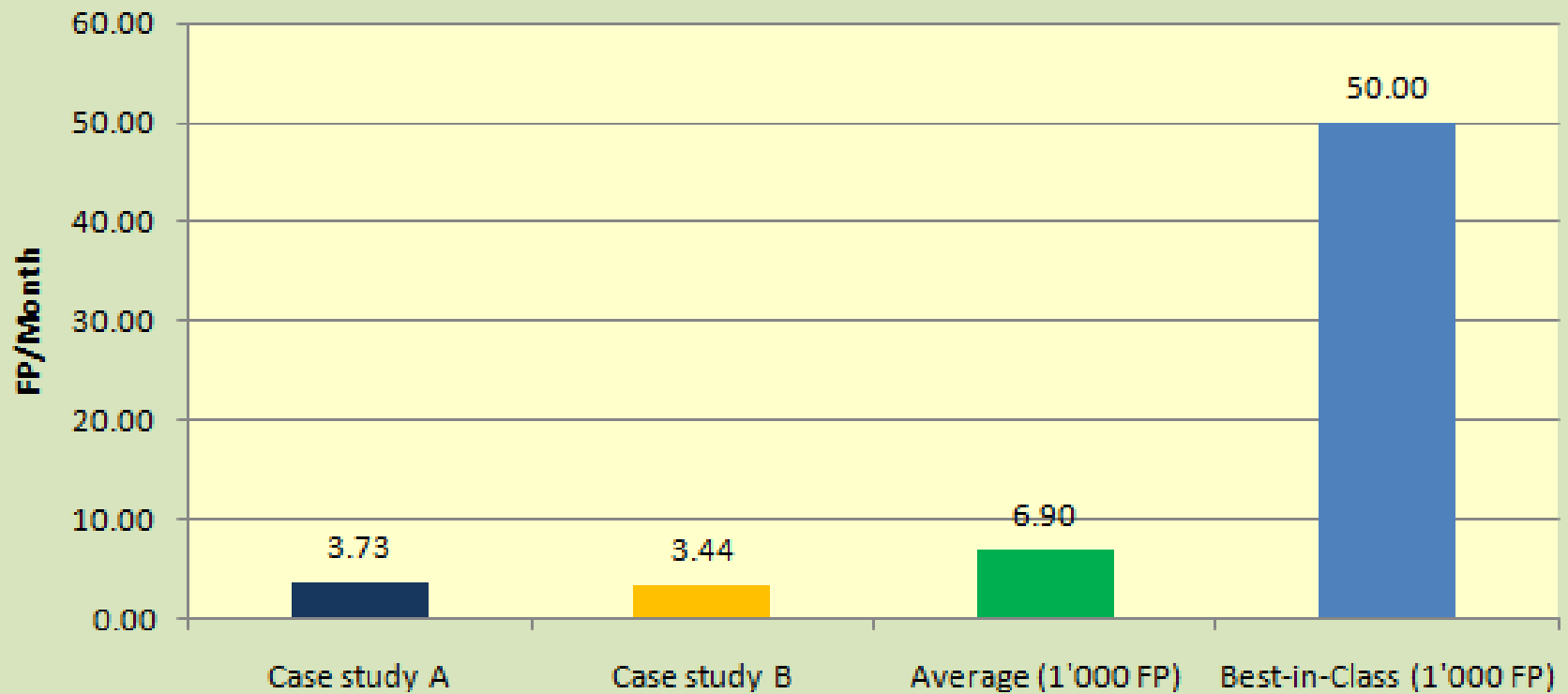
Effort





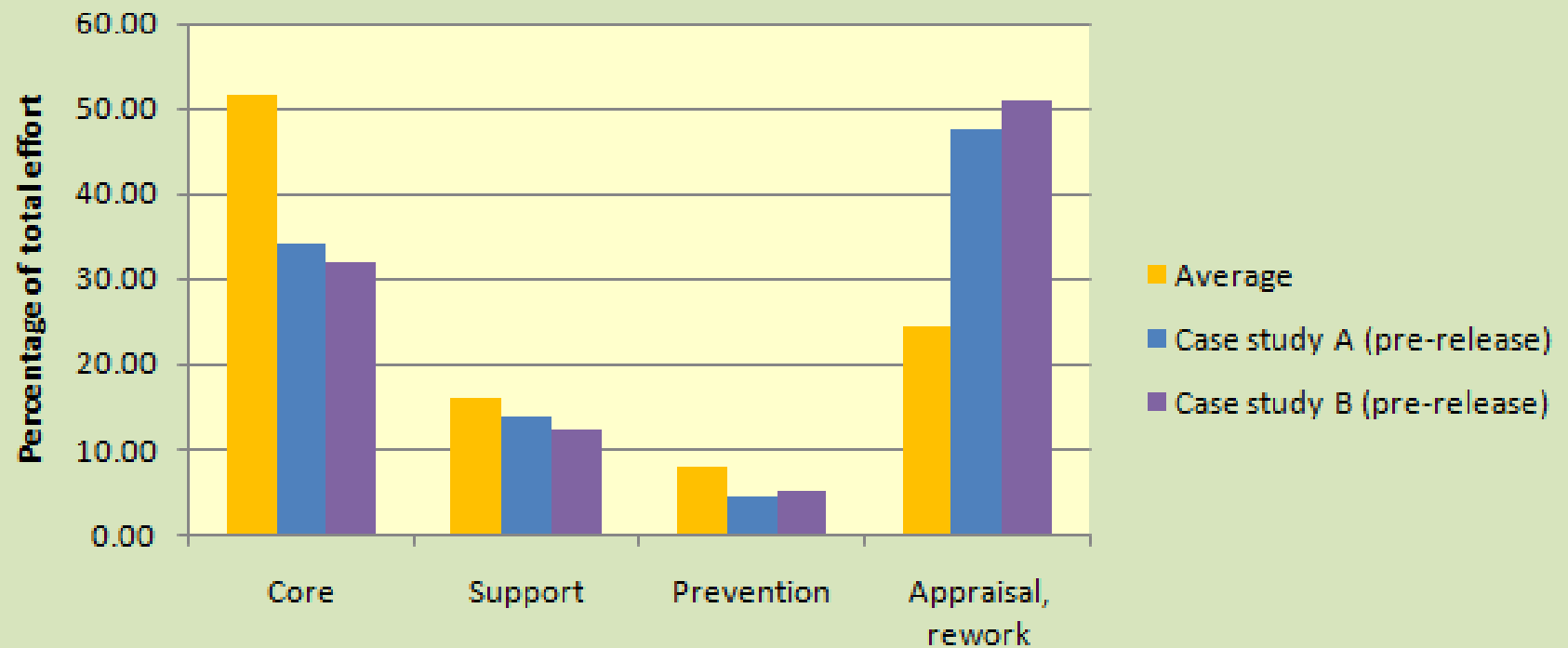


Productivity





Effort Distribution (process efficiency)





Defect Analysis (Example)

Project Support Toolkit
Product Quality (Reliability and Maintainability Indicators)

Product Quality: Actual

Size (LOC) 125'000

Total number of injected defects = 5'000

Defects	Requirements	Architecture	Low-level Design	Coding	Unit Testing	Integration Testing	System Testing	Maintenance
Residual	0	200	600	1'100	2'200	1'920	1'320	375
Injected	300	600	800	3'100	120	50	25	5
Removed	100	200	300	2'000	400	650	970	30
Remaining	200	600	1'100	2'200	1'920	1'320	375	350
Removal efficiency	33.3%	25.0%	21.4%	47.6%	17.2%	33.0%	72.1%	7.9%
Total injected	300	900	1'700	4'800	4'920	4'970	4'995	5'000
Total removed	100	300	600	2'600	3'000	3'650	4'620	4'650
Cumulative efficiency	33.3%	33.3%	35.3%	54.2%	61.0%	73.4%	92.5%	93.0%
Defect density	1.60	4.80	8.80	17.60	15.36	10.5	3.00	2.80

$$= (5'000 - 375) / 5'000$$

$$= 375 / 125$$

Range	Complexity distribution	Risk level
0 - 5	5.0%	Very low
5 - 10	25.0%	Low
10 - 20	20.0%	Moderate
20 - 50	35.0%	High
> 50	15.0%	Very high
Average	28.5	High

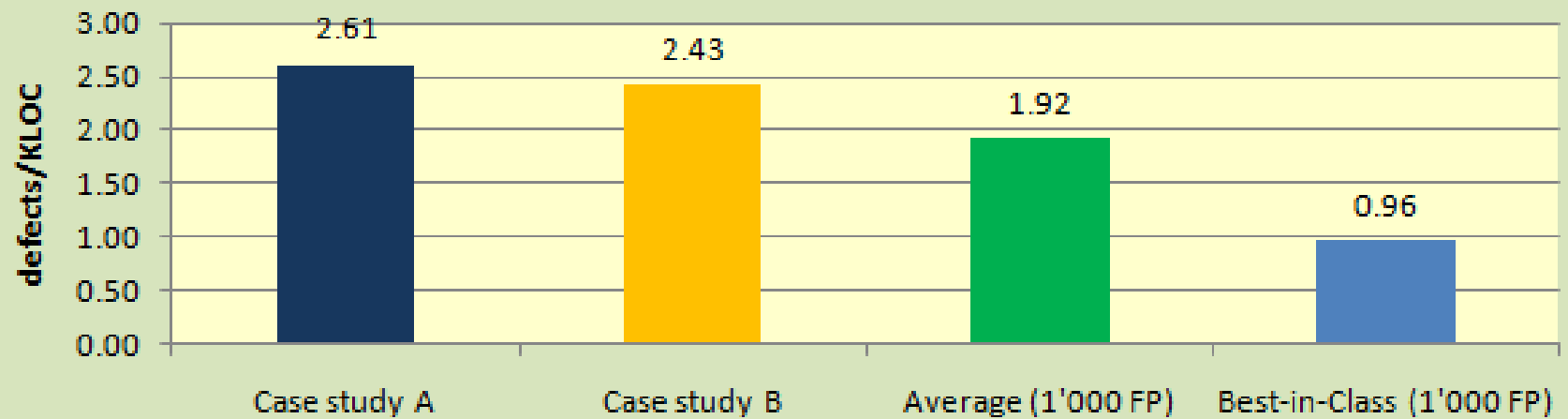
$$= 2.5 * 5 + 7.5 * 25 + 15 * 20 + 35 * 35 + 75 * 15$$

Test	Test coverage	Weight factor
Unit	30.0%	1
Integration	10.0%	3
System	10.0%	2
Overall	13.3%	Very low
Overall (summed)	50.0%	

$$= (1 * 30 + 3 * 10 + 2 * 10) / (1 + 3 + 2)$$

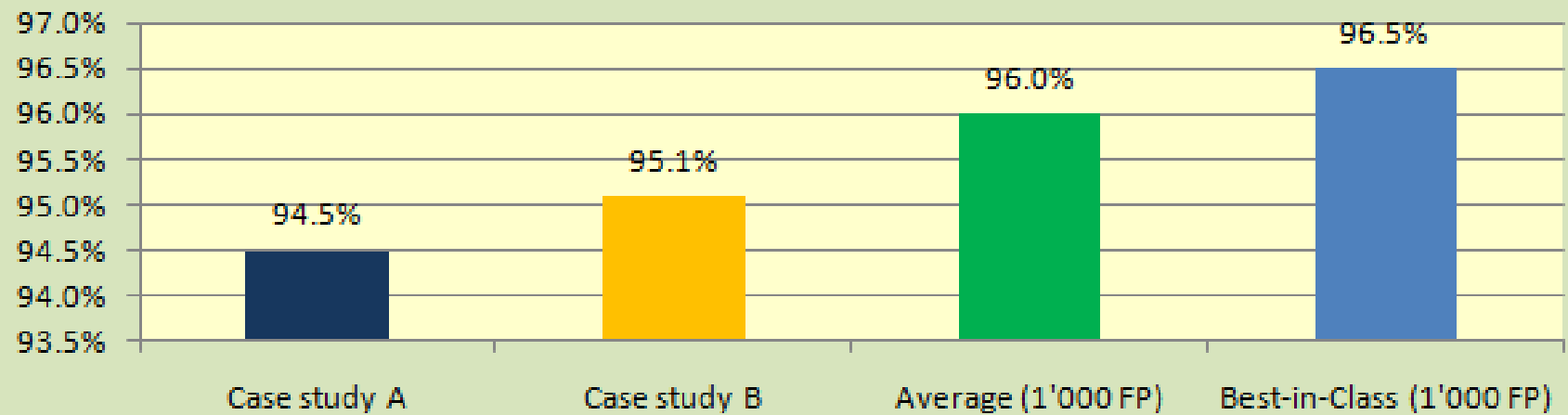


Defect Density





Removal Efficiency





Weakest Areas

1. Inefficient process

- Sum of appraisal and internal failure costs is high ($> 45\%$)
- Post-release distribution would even be worse!

2. Low code quality

- Code complexity is high (> 15)

These are the primary causes



Measure 1

- Increase prevention costs (training, reviews, inspections)
- Expected effects:
 - Will increase removal efficiency and lower defect density
 - Will decrease appraisal costs (testing) and rework costs (defect removal)
 - Will lead to faster schedule, lower effort and higher productivity



Measure 2

- Improve code quality
- Expected effects:
 - Will increase test coverage
 - Will (again) increase removal efficiency and lower defect density
 - Will (again) decrease appraisal costs (testing) and rework costs (defect removal)
 - Will (gain) lead to faster schedule, lower effort and higher productivity



6. Conclusions

- Process capability is not necessarily a good measure for high performance
- This does not mean that process improvement is bad
- To make it worth the investment, one should improve along a set of best practice KPIs instead of meeting the model/standard requirements only



KPIs as Improvement Drivers

- Once management starts actively using such KPIs, projects are forced to bring and keep not only their measurement process in place, but many other processes as well ...
 - Requirements Management
 - Project Planning
 - Project Monitoring and Control
 - ...



Another Capability Model ...

